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PERFORMANCE OPTIMIZATION OF INLINE EDFA-EYCDFA FOR MULTIPLE WAVELENGTH SERVICES IN OPTICAL COMMUNICATION SYSTEMS USING QUAD-SINGLE FORWARD AND TRI BACKWARD PUMPING TECHNIQUE

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Abstract

Proposed the inline EDFA-EYCDFA (Erbium Doped Fiber Amplifier - Erbium ytterbium co doped fiber amplifier) with Quad Pumping for multi wavelength services in optical communication systems using WDM technology. The proposed inline EDFA-EYCDFA model simulated by dual forward and backward pumping, dual-backward pumping, Tri-single forward and dual backward pumping and Quad-single forward and tri-backward pumping with respect to Pump power and fiber Length. The parameters Input optical power, output optical power, Gain, Noise figure, Forward noise power and backward noise power measured from all the types of pumping techniques from that the proposed inline EDFA-EYCDFA with Quad pumping gives high strength gain output with less forward noise power and backward noise power. Quad pumping is the best model suitable for multiple wavelength services in optical communication. The Results shown in Quad pumping Gain is maximum 28 dB and Forward Noise power is less -42.9dBm with the pump power of 20dB and fiber Length 5m.

Keywords:

Multiple Wavelength Services, EDFA, EYCDFA, WDM, Gain, Amplified Optical Power, Forward Backward Noise Power

1. INTRODUCTION

In the modern days to overcome the demand of data internet communication needs to require the fiber optic communication systems using WDM technology. WDM technology is very important nowadays for multiple signals transmitted in a single channel to avoid the cross talk effects for high performance services.

Fiber optic communication used as the WIFI fiber optic adapter carry the broad bandwidth optical signal in terms of Tb/s in communication systems used as telecommunication networks, Dispersions managed links, DWDM network based on optical packet switching, high speed WDM systems, Multi-vendor networks is the computer network supports tools from one more vendor or provider. The centralized computer network for business providing and high power operations and developing the idea environment that lets users attend to everyday challenges. Outer layer of the network performing centralized data centres enables to work network more intelligently. Data traffic kept very closer to customer gives services are faster, larger capacity with more efficient and also key management control and high secured functions operated centrally.

Optical amplifiers are the optical devices used to amplify the input optical signal directly with secured manner without the use of regenerators used in the fiber links. Examples are SOA, EDFA, EYCDFA, YDFA and RAMAN amplifiers and etc. From the all the types of optical amplifiers fiber doped optical amplifiers are the best one for getting high gain and less noise applications. Fiber doped optical amplifiers are EDFA, EYCDFA, YDFA and RAMAN amplifier. The characteristic of the EDFA is high gain EYCDFA is for getting less noise, YDFA for amplification purpose, RAMAN for pump independent purposes. The EDFA and EYCDFA is the best optical fiber amplifiers used in the optical communication systems.

The paper organized into five sections. Section 2 explains the background of this work, while section 3 presents the proposed work with simulation models. Section 4 demonstrates the model Simulation results and finally, the paper concluded in section 5.

2. BACKGROUND

The paper [4] executed the comparison between the received optical power is kept approximately same at receivers end and he total span distance between the transmitter and receiver is also kept constant using WDM technique to elevate the capacity used different configurations EDFA, RAMAN and EDFA-RAMAN. This paper [5] discussed the upgrading optical communication capacity with different modulation using DWDM technique. Gain noise figure, BER and quality factor analyzed with respect to the fiber length. The paper [7] Discusses EDFA with WDM technology modeled through optimized fiber length and pumping power variation, gain and noise figure. The paper [8] discussed about EDFA with four stage enhancement to measure the gain and noise figure outputs. The paper [9] developed the EDFA-EYCDFA cascading amplifier obtained the flattening gain and noise figure.

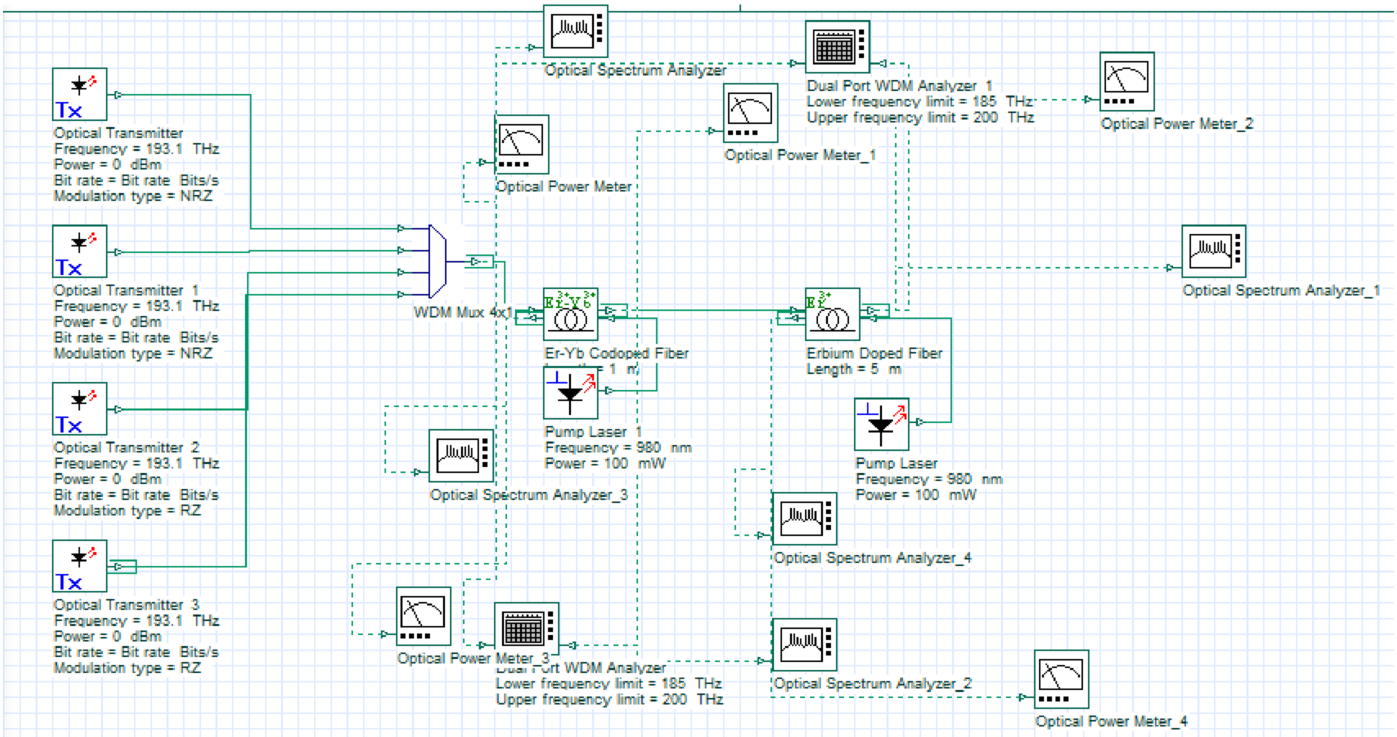
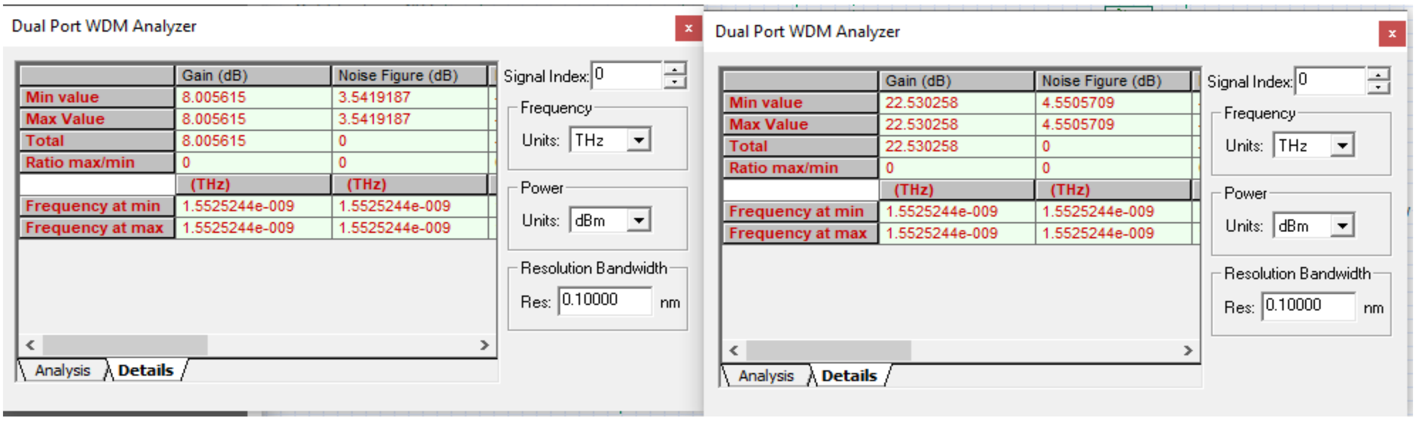


Fig.1. Inline EYCDFA -EDFA with dual backward pumping Simulation Model



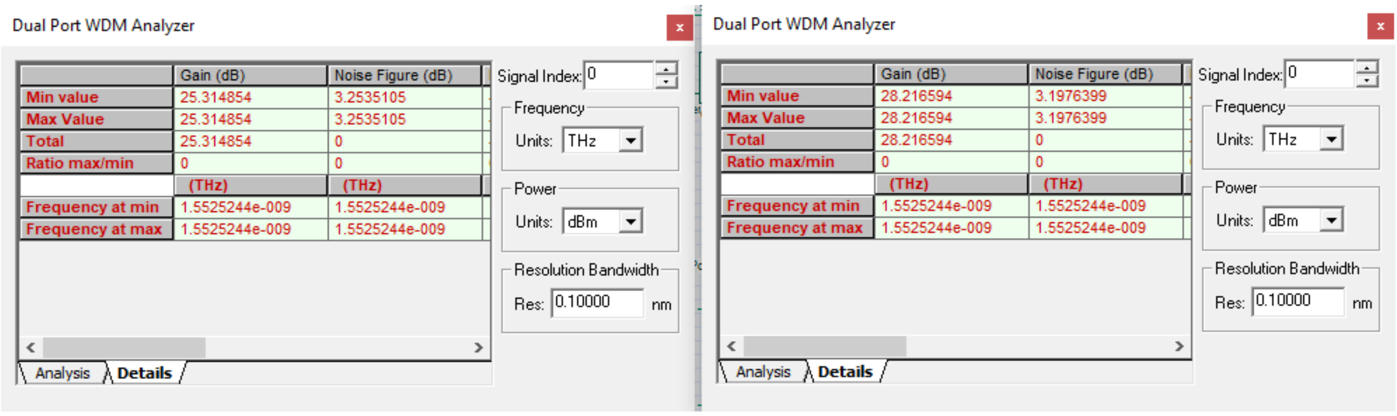
Dual Port WDM Analyzer

	Gain (dB)	Noise Figure (dB)
Min value	8.005615	3.5419187
Max Value	8.005615	3.5419187
Total	8.005615	0
Ratio max/min	0	0
	(THz)	(THz)
Frequency at min	1.5525244e-009	1.5525244e-009
Frequency at max	1.5525244e-009	1.5525244e-009

Dual Port WDM Analyzer

	Gain (dB)	Noise Figure (dB)
Min value	22.530258	4.5505709
Max Value	22.530258	4.5505709
Total	22.530258	0
Ratio max/min	0	0
	(THz)	(THz)
Frequency at min	1.5525244e-009	1.5525244e-009
Frequency at max	1.5525244e-009	1.5525244e-009

Fig.2. Inline EYCDFA -EDFA Dual port WDM analyzer output with Dual forward and backward pumping simulation Model



Dual Port WDM Analyzer

	Gain (dB)	Noise Figure (dB)
Min value	25.314854	3.2535105
Max Value	25.314854	3.2535105
Total	25.314854	0
Ratio max/min	0	0
	(THz)	(THz)
Frequency at min	1.5525244e-009	1.5525244e-009
Frequency at max	1.5525244e-009	1.5525244e-009

Dual Port WDM Analyzer

	Gain (dB)	Noise Figure (dB)
Min value	28.216594	3.1976399
Max Value	28.216594	3.1976399
Total	28.216594	0
Ratio max/min	0	0
	(THz)	(THz)
Frequency at min	1.5525244e-009	1.5525244e-009
Frequency at max	1.5525244e-009	1.5525244e-009

Fig.3. Inline EYCDFA - EDFA Dual port WDM analyzer output with Quad pumping Simulation Model

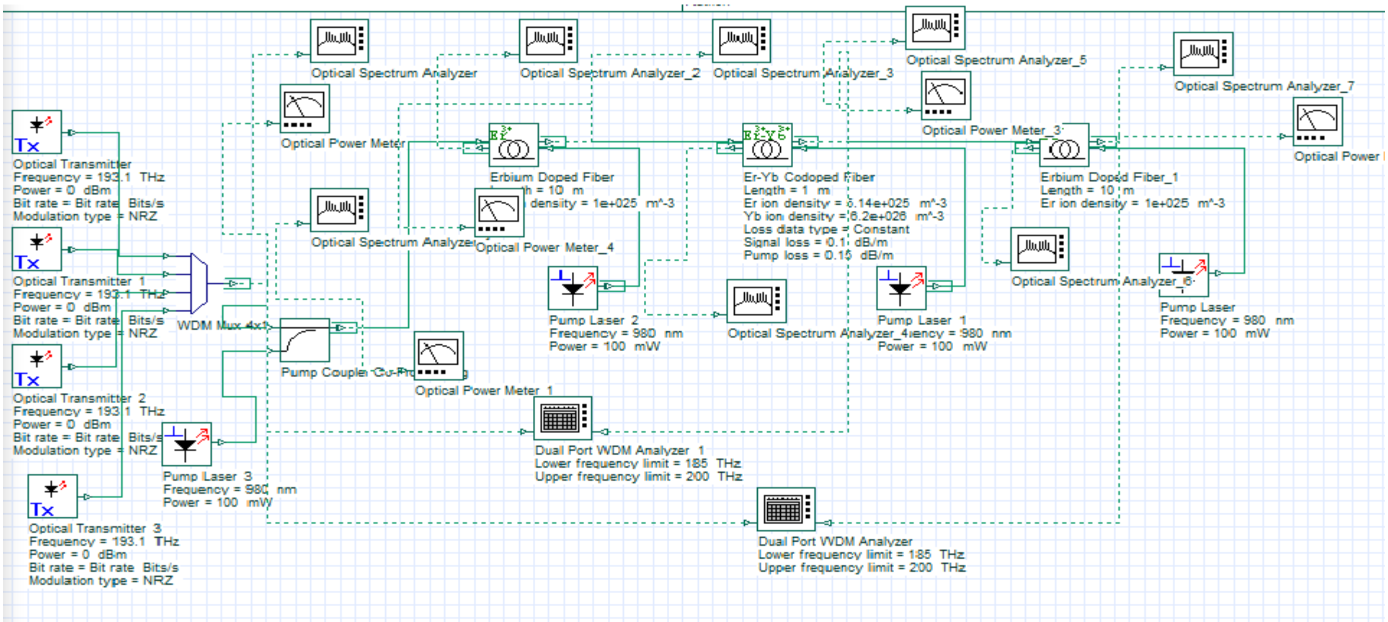


Fig.4. Simulation model with Quad pumping (Single forward and Tri backward) of EYCDFA and 2 stage EDFA

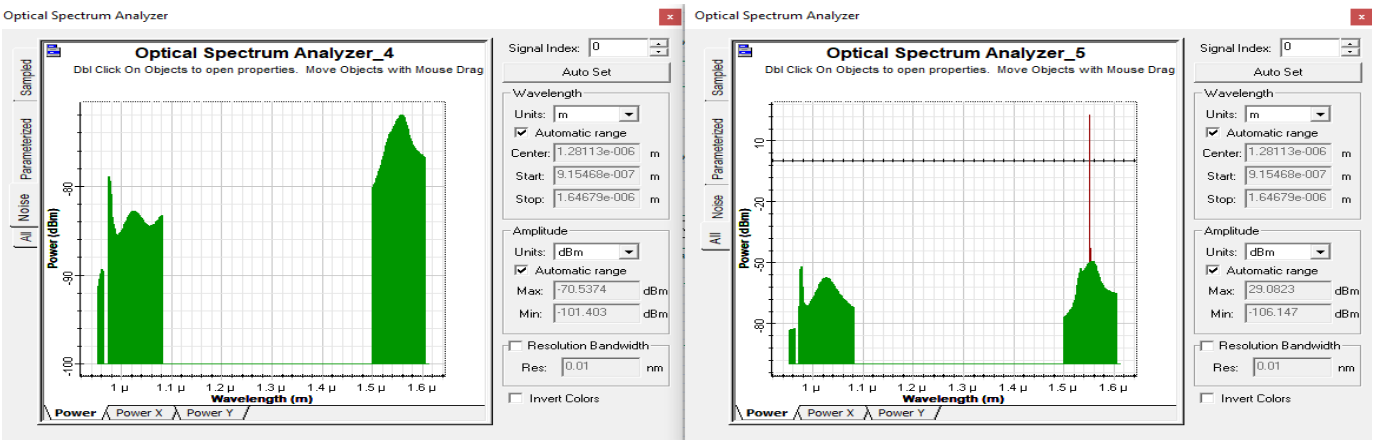


Fig.5. OSA output of Quad Pumping technique

3. PROPOSED WORK WITH SIMULATION MODEL

The Proposed work Quad pumping - EYCDFA and two stage EDFA connected together as shown in Fig.4. with respect to the pump power and Fiber length consists of two optical transmitters having the frequency range 193.1THz, input power of 0dBm (1mW), the bit rate of 1×10^{10} Bits/s and the modulation type is NRZ and two optical transmitters having the frequency range 193.1THz, input power of 0dBm (1mW), the bit rate of $1X10^{10}$ Bits/s and the modulation type is RZ, totally four optical transmitters are transmitting by single channel. Four input signal channels multiplexed with 4:1 multiplexer, output given to EDFA1 and output connected to EYCDFA.

EYCDFA consists of 4 ports two inputs and two outputs. EYCDFA output connected to first input of EDFA2. Optical transmitters are the single channel version of WDM components. optical transmitters consists of Duty cycle 0.5, used the external modulation or direct modulation type, separation frequency 75GHz and emission frequency 850nm and extinction ratio is 10db and line width is 10MHz and 64 samples/bit. WDM uses the bandwidth 10GHz and depth 100dB, Bessel filter used to filter unwanted wavelengths, Channel frequencies are 193.1.193.2, 193.3 and 193.4THz. EYCDFA is fiber optic erbium and ytterbium co doped fiber amplifier uses length 1m, Erbium ion density 5.14e+025mm, Ytterbium ion density 6.2e+026mm, Erbium Meta stable lifetime 10ms and ytterbium Meta stable lifetime of 1.5ms. Erbium fiber optic amplifiers stage1 and stage2 uses length 5m, erbium ion density 1e+025mm and erbium Meta stable life time of 10ms.

Fig.1. denotes the Inline EDFA-EYCDFA with single forward and single backward pumping scheme. Similarly the other dual forward pumping and tri pumping models connected together with EDFA and EYCDFA. Optical Power meter connected output of each device to display the output optical power. Dual port WDM analyzer connected between input and output to measure gain and noise figure, Optical spectrum analyzer (OSA) connected front and back sides EDFA and EYCDFA to measure the forward and backward signal and noise powers.

4. RESULTS AND DISCUSSIONS

The Proposed Quad pumping simulation model produced the Optimized output optical power, maximum gain, less noise figure, minimum forward and backward noise power compared to the Dual forward and backward pumping, dual forward Pumping and TRI - single forward and dual backward pumping schemes shown in Fig.1.

The Fig.2. and Fig.3 shows the left side of dual port WDM analyzer measures the gain of EYCDFA with respect to multiplexed input and right side of the WDM analyzer shows the gain of EDFA with respect to multiplexed input.

Table.1. Optical power, Gain, Noise Figure, forward and Backward Noise power of various pumping techniques with input 1mw and pump power 20dB

EDFA=5m, EYCDFA=1m, Pump power=20dB and Input power=1mw (0dB)					
Parameter	**Optical Power (dBm)**	**Gain (dB)**	**Noise Figure (dB)**	**Forward Noise Power (dBm)**	**Backward Noise Power (dBm)**
Dual Forward and Backward Pumping	17	20.5	5.95	-50.55	55.5
Dual backward Pumping	19.17	21.1	11.75	-33.25	-51
Tri - single forward and dual backward pumping	19.6	21.6	4.38	-32.4	-62.2
Quad - single forward and tri-backward pumping	**23.3**	**26.3**	**3.29**	**-44.6**	**-66.8**

The Table.1, Table.2, and Table.3 shows the results measured each and every stage of EDFA and EYCDFA the optical output power using the optical meter and gain and noise figure values are measured from Dual port Wavelength division multiplexer Analyzer connected between input and output as shown in Fig 2 and Fig 3.

Table.2. Optical power, Gain, Noise Figure, forward and Backward Noise power of various pumping techniques with input 1mw and pump power 22dB

EDFA=5m, EYCDFA=1m, Pump power=22dB and Input power=1mw(0dB)					
Parameter	**Optical Power (dBm)**	**Gain (dB)**	**Noise Figure (dB)**	**Forward Noise Power (dBm)**	**Backward Noise Power (dBm)**
Dual Forward and Backward Pumping	19.5	22.5	4.55	**-49.8**	57.44
Dual backward Pumping	21.59	23.26	9.8	-29.2	-55
Tri - single forward and dual backward pumping	22.2	23.5	3.8	-26.9	-62.8
Quad - single forward and tri-backward pumping	**25.2**	**28.2**	**3.19**	**-42.9**	**-66.8**

Forward and backward noise power measured from Optical spectrum analyzer (OSA) connected each stage as shown in Fig.5. OSA used to measure the Forward and backward signal and noise power in power and wavelength spectrum analysis.

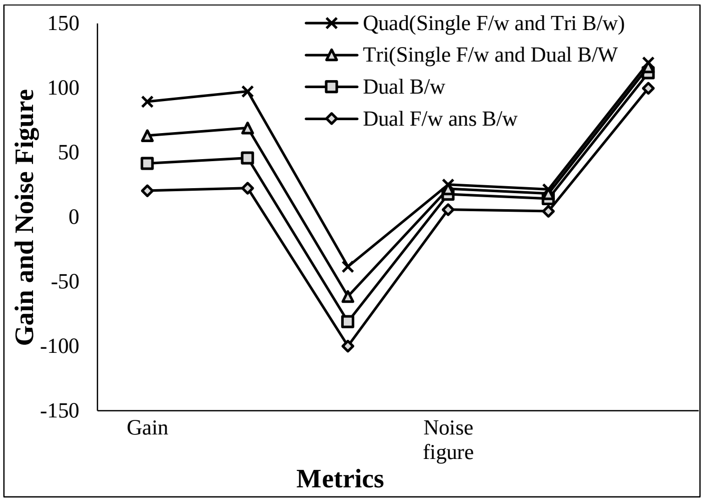


Fig.6. Gain noise figure with all pumping

Table.3. Optical power, Gain, Noise Figure, forward and Backward Noise power of various pumping techniques with input 1mw and L=10m and pump power 20dB

EDFA=10m, EYCDFA=1m, Pump power=20dB and Input power=1mw(0dB)					
Parameter	**Optical Power (dBm)**	**Gain (dB)**	**Noise Figure (dB)**	**Forward Noise Power (dBm)**	**Backward Noise Power (dBm)**
Dual Forward and Backward Pumping	-1	-100	100	10	10
Dual backward Pumping	19	20.97	11.8	-33.7	-49.8

Tri - single forward and dual backward pumping	19.5	21.3	4.85	-32.4	-58.7
Quad - single forward and tri-backward pumping	**23.2**	**26.1**	**3.18**	**-38.2**	**-61.9**

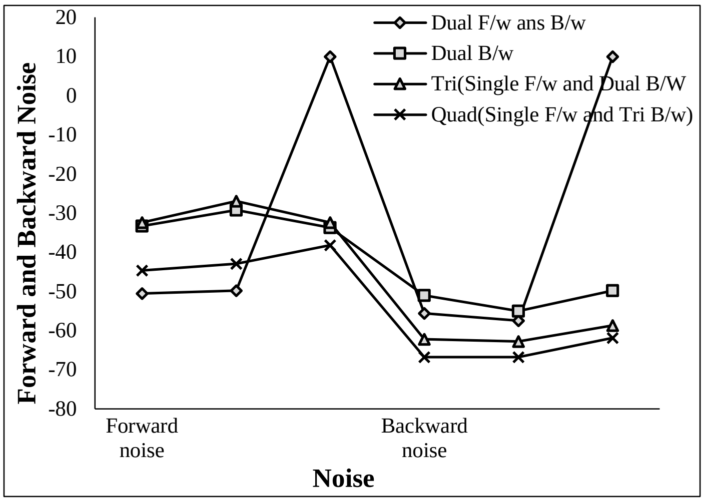


Fig.7. Forward and Backward noise with all pumping methods

The Fig.6. Shows the Gain and noise figure variations plotted in line graph with all pumping techniques. The Fig.7 shows the Forward and Backward noise is plotted using line graph in excel and gives minimum forward and backward noises in quad pumping technique.

The Fig.8 shows the line graph plotted as gain and optical power variations in all pumping methods. The Fig.9. shows the Gain variation separately plotted in all pumping methods. Fig.10. shows the line graph Noise Figure plotted separately with all pumping methods.

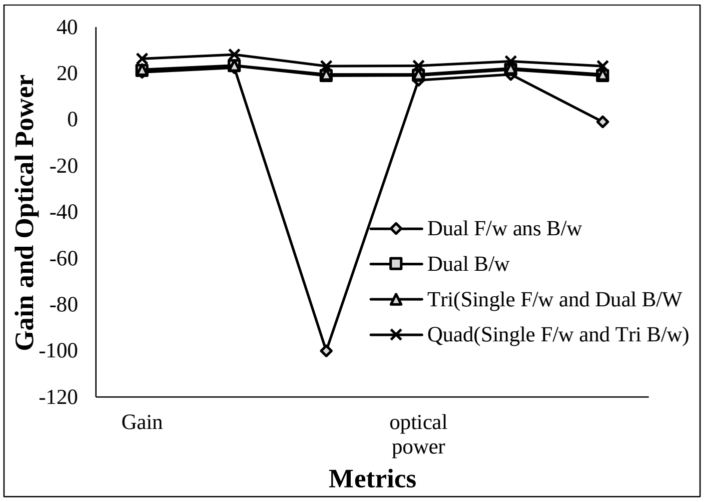


Fig.8. Gain optical power with all pumping methods

Finally in all line graphs shows the quad pumping gives better result than other pumping techniques. Gain maximum, less noise figure, optimum optical power and less forward and backward noises obtained when the pump power increases to 150mw compared to the normal pump power 100mw and increases length range from 5m to 10m.

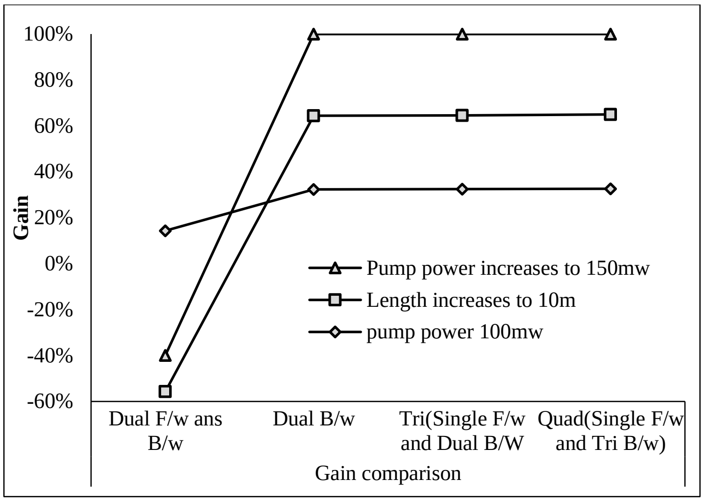


Fig.9. Gain with all pumping methods

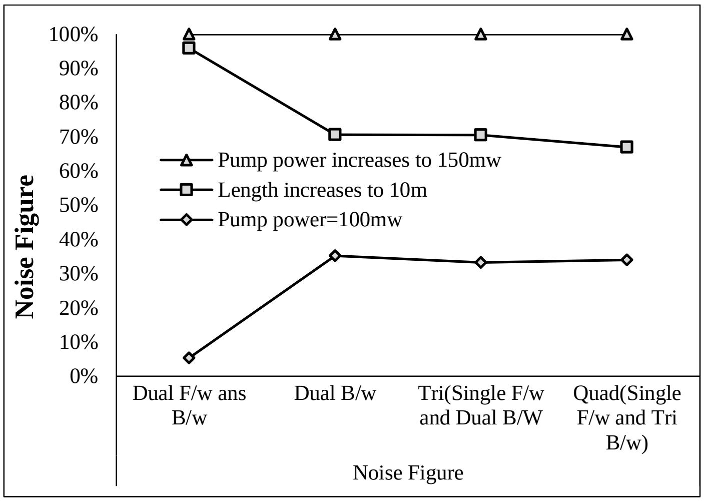


Fig.10. Noise Figure with all pumping methods

5. CONCLUSION

We summarize the inline EDFA-EYCDFA model successfully simulated with various pumping techniques. From the all types of pumping Quad pumping is the best model for optical fiber communication with multiple wavelength services. The Inline EDFA-EYCDFA model simulated using pump power and fiber length and obtained the output parameters output optical power, Gain, Noise Figure, Forward noise power and backward noise power measured from output of every device and tabulated the measured values and analyzed. Quad - single forward and tri-backward pumping gives the optimized gain and less noise and can be the best model for optical internet data communication using fibers.

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